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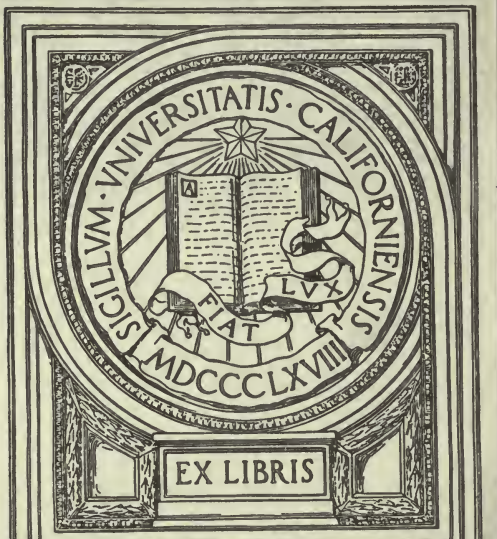
Anatomy and physiology of the eye and its appendages.



ANATOMY AND PHYSIOLOGY

OF THE

EYE AND ITS APPENDAGES

BY

JOHN WELSH CROSKEY, M. D.

OPHTHALMIC SURGEON

TO THE

PHILADELPHIA GENERAL HOSPITAL

Philadelphia, Pa.

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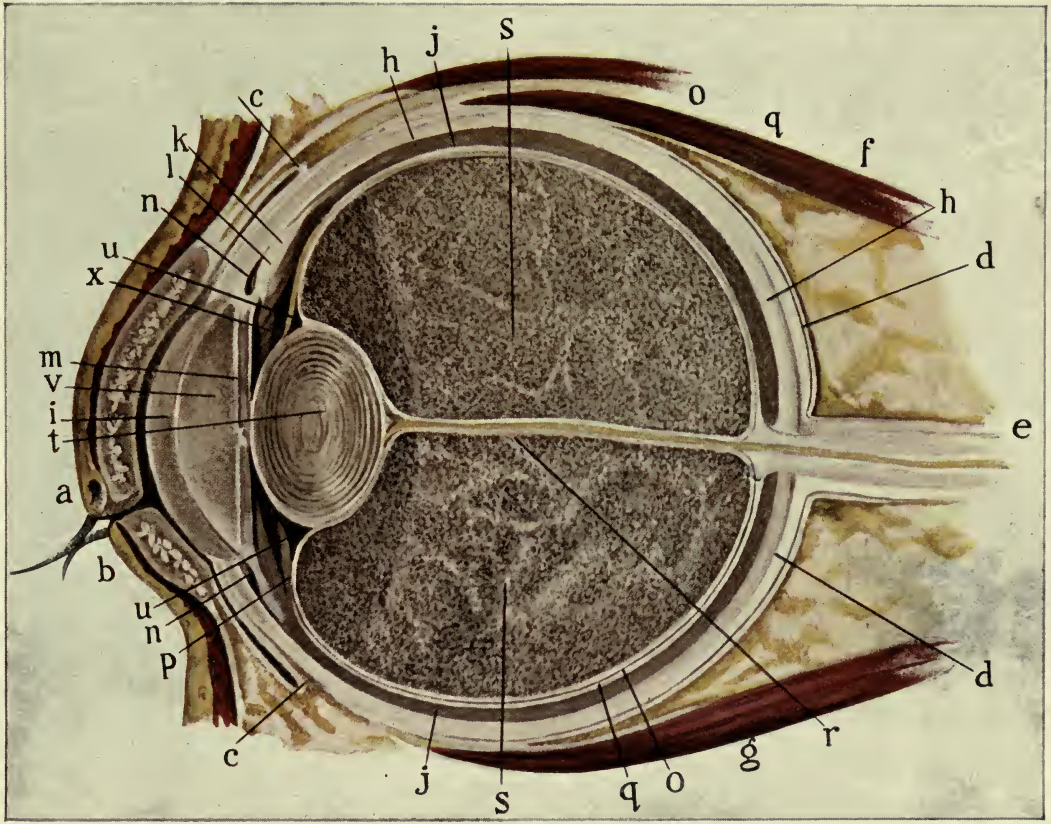

PLATE 1

a, Superior (upper) eyelid. *b*, Posterior (lower) eyelid, showing its different layers. *c*, *c*, Reflection of the conjunctiva on the posterior face of the eyelid and on the anterior face of the ocular globe. *d*, *d*, Orbito ocular aponeurosis, prolonged on *e*. the sheath of the optic nerve, and on the sheaths of the muscles. *f*, Superior rectus. *g*, Inferior rectus. *h*. *h*, Sclerotic coat, thickened posteriorly by the sheath of the optic nerve, anteriorly by the expansion of the aponeurosis of the recti muscles. *i*, Transparent cornea cut to show its laminated texture. *j*, *j*, Choroid coat. *k*, Ciliary circle. *l*, Ciliary bodies and processes. *m*, Iris, showing pupil. *n*, *n*, Canal of Fontana. *o*, *o*, Retina. *p*, Ciliary circle of Zinn. *q*. *q*. Hyaloid membrane. *r*, Capsular artery in the hyaloid canal. *s*, *s*, Vitreous humor. *t*, Crystalline lens in its capsule. *u*, *u*, Canal of Petit. *v*, Anterior Chamber. *x*, Posterior Chamber.

PREFACE

This little pamphlet is the outgrowth of the instruction given to students and nurses at the Philadelphia General Hospital during the past ten years. The author believes that if the anatomy of the eye is thoroughly understood, it renders subsequent study less difficult.

Every effort has been made to simplify the text so that the subject matter can be readily understood.

The author's thanks are due to his son-in-law, Mr. Lewis Elberon Bailey, for the two most excellent illustrations.

DEDICATION

Affectionately dedicated
to
my preceptor, the late Henry Earnest Goodman, M. D.,
to whom I owe much of my success.

Anatomy and Physiology of the Eye and its Appendages

JOHN WELSH CROSKEY, M. D.
OPHTHALMIC SURGEON
TO THE
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ANATOMY.

THE EYE is the organ of vision.

VISION is the faculty or sense of sight.

THE ORBITS are the cavities which contain the eyeball, and are four-sided, pyramidal, boney cavities, with the bases in front and the apices behind. They are formed of seven bones: superior maxillary, malar, frontal, palate, sphenoid, ethmoid and lachrymal.

The orbital plate of the superior maxillary, a portion of the malar, the orbital process of the palate bone form the floor of the orbit. The orbital plate of the frontal and a small portion of the sphenoid form the roof. The ethmoid, lachrymal, sphenoid and the nasal process of the superior maxillary form the inner wall, while the outer wall is formed by the sphenoid and malar.

THE FLOOR OF THE ORBIT is inclined, being higher on the nasal side than on the temporal side. It is thin and smooth and separates the orbital cavity from the antrum of Highmore.

THE ROOF OF THE ORBIT, except at its margins and especially the anterior margin, is very thin, is easily penetrated and quite unable to resist pressure from either side. On its opposite sides are the frontal sinus anteriorly, and the cranial cavity posteriorly.

The anterior margin of the roof is thick and overhangs the orbital cavity. The inner wall is extremely thin and upon its opposite side, in front, is the frontal sinus; below and behind is the nasal cavity. The outer wall is very thick at the rim, thin immediately behind the rim, then thick again on the sphenoidal portion. On the opposite side of the frontal half of this wall is the temporal fossa. At the posterior portion, the wall separates the orbit from the cranial cavity and at its extreme portion, both cavities are united through the sphenoidal fissure.

THE FORAMINA OF THE ORBIT are nine in number:

1. THE OPTIC FORAMEN, for the passage of the optic nerve and ophthalmic artery.

2. THE SPHENOIDAL FORAMEN (fissure Foramen Lacerum Anterius), for the passage of the third, the fourth, the ophthalmic division of the fifth and sixth cranial nerves, some filaments from the cavernous plexus of the sympathetic, the orbital branch of the middle miningeal artery, a recurrent branch from the lachrymal artery to the dura mater, and the ophthalmic vein.

3. THE SPHENO MAXILLARY FORAMEN (fissure), for the passage of the superior maxillary nerve and its branches, the infraorbital artery and ascending branches from Meckel's ganglion.

4. THE LACHRYMAL FORAMEN (groove), is occupied by the lachrymal or nasal duct.

5. THE SUPRAORBITAL FORAMEN (sometimes a groove), for the passage of the supraorbital artery, vein and nerve.

6. THE INFRAORBITAL FORAMEN (groove), for the passage of the infraorbital nerve and artery.

7. THE MALAR FORAMEN (sometimes two), for the passages of the facial nerve and vessels.

8 and 9. THE ANTERIOR AND POSTERIOR ETHMOIDAL FORAMINA, for the passage of the anterior Ethmodial artery and the nasal nerve.

The orbit is lined by periosteum which, after entering the orbit through the optic foramen, is divided into two parts: one part lining the orbit and the other part continuing in a fibrous sheath known as Tenon's capsule, which invests the posterior parts of the eyeball.

As the periosteum enters the orbit through the optic foramen it forms a tendinous ring, which ring gives origin to the ocular muscles.

THE ORBITAL PERIOSTEUM is covered with a layer of connective tissue and fat, upon which the eye rests.

In the roof of the orbit are two depressions: the fovea trochlaris at the inner angle, and the fossa lachrymalis at the outer anterior angle.

THE EYE LIDS.

THE EYE LIDS are the curtains, movable at will, that cover the eyeballs in front. They are the appendages of the eye and are composed of integument, connective tissue, orbicularis, palpebrarum muscle, tarsal cartilage, Meibomian glands, and conjunctiva.

The opening formed by the edges of the lids is called the palpebral fissure. This fissure at the outer side is called the outer canthus, at the inner side the inner canthus. The outer canthus is more acute than the inner, and the lids here lie in close contact with the globe; but the inner canthus is prolonged for a short distance inwards, towards the nose, where the two lids are separated by a triangular space called the lachrymal lake or *lacus lachrymalis*.

The lids contain a semilunar framework of condensed connective tissue which is called the tarsal cartilage. This gives the lids their shape and firmness. In the upper lid it is oval and is thickest at its anterior edge. In the lower lid it is thinner and narrower and is of nearly uniform breadth throughout. The lids are held firmly in position by fibrous tissue internally to the tendo oculi, externally to the malar bone, and above and below to the margins of the orbit by the palpebral ligament. The upper lid contains about 30 large sebaceous glands called Meibomian glands, and the lower lid contains about 20. The ducts from these glands open on the free borders of the posterior lip of each lid. Their function is to secrete a sebum which lubricates the edges of the lids, preventing them from sticking together and also preventing the overflow of the lachrymal secretions.

The Eyelashes (*Cilia*) are attached to the free edges of the eyelids. They are short, thick, curved hairs, arranged in a double or triple row at the margin of the lids; those of the upper lid are more numerous and longer than the lower, and are curved upwards; those of the lower lid are curved downwards, by which means they do not interlace on closing the lids.

The Conjunctiva coats the posterior surface of each lid and also the anterior surface of the eyeball. It is divided into three portions: the part covering the posterior surface of each lid, which is known as the conjunctiva tarsi; that part which coats the anterior surface of the eyeball called the conjunctiva bulbi and the connection between these two parts which is called Conjunctiva Fornix. The conjunctiva tarsi is best seen by everting the lid. It has a smooth surface and is intimately and immovably adherent to the lids.

The Region of Transition (*or fornix*) is very readily brought to view in the lower lid by drawing the lid down while the eye looks up. In the upper lid, on the contrary, the fold of transition is hard to see, unless we make a double eversion of the lid. The region of transition is the loosest part of the conjunctiva, being so abundant that it lies in horizontal folds. This arrangement insures the eye its free power of movement. If the conjunctiva were to pass directly from the lid to the eye, as is sometimes observed in consequence of disease of the conjunctiva, every movement of the eyeball would be transmitted to the lids; and if one of the lids were held still with the finger, the eyeball would be hampered by it in its movements. The conjunctiva is present in such quantity at the fornix that the eye is able to move in complete independence of the lids, the folds in the region of transition being smoothed out or crumpled together, as the movement may require. Appearing through the lower fold of transition are the extensive subjacent plexus of veins and also the white glistening fascia. Its lax character and also its abundant blood supply render the fold of transition particularly liable to great swelling in inflammations of the conjunctiva.

The microscope shows that the palpebral conjunctiva is covered with a laminated cylindrical epithelium. The mucous membrane proper is of adenoid character—that is, even in the healthy state it contains an abundant quantity of round cells (*lymph corpuscles*), which notably increase in number with every inflammation of the conjunctiva. Of glands it possesses acinous mucous glands, which are found along the convex border of the tarsus. Analogous glands are present in the fornix conjunctiva.

The conjunctiva of the upper lid obtains its blood supply from two arterial arches, the arcus tarseus superior and the arcus tarseus inferior. These lie upon the anterior surface of the tarsus, near its upper and its lower edges. To reach the conjunctiva, the branches of the arcus tarseus inferior perforate the tarsus through its entire thickness from before backward, two or three m.m above the free edge of the lid. The line along which the vessels come out from the tarsus is marked by a shallow furrow (sulcus subtarsalis) on the conjunctival surface of the lid. On the lower lid there is only one arterial arch.

THE CONJUNCTIVA BULBI covers the anterior surface of the eyeball. It has no aperture corresponding to the cornea, but continues, even if with altered character, over the latter. This continuity of the conjunctiva makes it plain to us why morbid processes of the latter do not stop at the margin of the cornea but are continued upon its surface, as we see very clearly in trachoma and in conjunctivitis eczematosa. The two divisions of the conjunctiva bulbi are distinguished as the conjunctiva scleræ and conjuctiva cornea.

THE CONJUNCTIVA CORNEA is perfectly transparent, and is so intimately adherent to the cornea proper that it must be regarded as the uppermost layer of the latter, and is better treated in connection with the cornea itself.

THE CONJUNCTIVA SCLERAE covers the anterior segment of the sclera in the form of a thin pellicle. It is connected with the sclera by lax connective tissue (the episcleral tissue) so loosely that it can readily be moved about from side to side upon the sclera. It is only at the periphery of the cornea, where it ends in a sharp edge, the limbus (*Limbus-hem*) conjunctiva, that the conjunctiva scleræ is intimately adherent to its substratum. It is very thin and elastic and lets the white sclera be seen through it plainly, thus forming the *"white of the eye."*

In old people there is a spot at the inner and the outer margins of the cornea which contrasts by its yellow color with this whiteness. This has the shape of a triangle with its base at the corneal margin, and projects a little above the rest of the conjunctiva. It is called the interpalpebral spot or the pinguecula, and is caused by an alteration, that has taken place in the tissues of that part of the conjunctiva which, being included in the interpalpebral fissure, is constantly exposed to atmospheric influences.

The conjunctiva scleræ is covered with laminated pavement epithelium and contains no glands. At the inner angle of the eye it forms a crescentic duplication, the semilunar fold (*plica semilunaris*), which represents an abortive remnant of the palpebra tertia of animals. To the inside of the semilunar fold is a small, reddish, nipple-like prominence, the caruncle, which occupies the bottom of the horseshoe-shaped excavation at the angle of the eye. This is shown to be histologically a small island made of skin, containing sebaceous and sweat glands and having its surface covered with delicate, light-colored hairs.

The conjunctiva of the eyeball receives its blood vessels chiefly from the vessels of the fold of transition—the posterior conjunctival vessels. Furthermore, the anterior ciliary vessels take part in supplying the conjunctiva with blood. These vessels come from the four recti muscles and run under the conjunctiva (through which they are visible, shining with a

bluish luster) until near the edge of the cornea, where they suddenly disappear, since they pass through the sclera into the interior of the eye. But, before this happens, they give off branches which end in vascular loops, in the limbus conjunctiva directly at the margin of the cornea (*marginal network of the cornea*). This latter is of great importance for the cornea, which is chiefly dependent upon it for nutrition. Other branches of the ciliary vessels (*anterior conjunctival vessels*) run backward in the conjunctiva toward the posterior conjunctival vessels and anastomose with them.

We have, therefore, in the conjunctiva two vascular systems—that of the posterior conjunctival vessels and that of the anterior ciliary vessels. According as the one or the other system is over distended with blood, the conjunctiva has a different aspect, which we designate respectively as conjunctival and as ciliary injection.

The Lachrymal Apparatus.

The Lachrymal Apparatus consists of the lachrymal gland and the lachrymal passages.

The Lachrymal Gland (*glandula lacrimalis*) is an acinous gland which consists of two divisions. The larger of these, known as the superior lachrymal gland, lies in the upper external angle of the orbit in a depression in the bony wall of the latter, the fossa glandulæ lacrimalis. The excretory ducts of the superior lachrymal gland pass downward and empty into the external half of the superior fornix conjunctiva.

The second division of the lachrymal gland—the inferior lachrymal gland—is much smaller, and consists only of one or two lobules, for which reason it is also known as the accessory lachrymal gland. Its lobules lie along the excretory ducts of the superior gland directly beneath the mucous membrane of the fornix. If the upper lid is everted and at the same time the eye is made to look downward, we often see the conjunctiva of the fornix in the vicinity of the outer angle of the lid pushed forward by a soft mass which is in fact the inferior lachrymal gland. Krause's glands form a sort of continuation of the lobules of the inferior lachrymal gland over the fornix as far as its inner end. Their structure is that of the lachrymal gland, so that they may be regarded as the ultimate scattered outlying portions of the latter.

The Lachrymal Passages begin with the puncta lacrimalia. These lie on the free border of the upper and lower lid (*upper and lower punctum*). In its downward course the lachrymal duct deviates a little backward and outward from the vertical. Hence the two lachrymal channels diverge as they go down, the lachrymal sacs being less far apart than are the lower orifices of the lachrymal ducts. We can represent the course of the lachrymal channel on the living subject by placing a straight sound in such a way as to lie at its upper part upon the middle of the internal palpebral ligament, and below upon the furrow forming the boundary line between the cheek and the alæ of the nose. The position of this sound gives precisely the direction of the lachrymal duct. If we place a sound in this way on each

side of the nose, we see how the sounds diverge as they go down, and we can readily convince ourselves that the degree of divergence differs in different individuals. The divergence, in fact, depends upon the breadth of the root of the nose on the one hand, and upon the breadth of the inferior nasal orifice on the other. These facts are of importance with regard to the operation of sounding the lachrymal duct, in the performance of which the sound must be pushed along in the direction of the duct.

The mucous membrane of the lachrymal sac and that of the lachrymal duct form one continuous whole. There is, therefore, no sharp dividing line between these two structures. They are mainly distinguished by the fact that the lachrymal sac lies against the bone (*the lachrymal bone*) at one side only, and everywhere else is free, while the lachrymal duct is inclosed on all sides by boney walls. It follows from this that, in engorgement of the lachrymal channels with fluid, it is only the lachrymal sac which is distended so as to appear as a visible swelling at the inner angle of the eye. The lachrymal duct cannot be distended; on the contrary, it is the favorite seat of constrictions, which again do not occur in the lachrymal sac. The formation of these constrictions is facilitated by the fact that a dense plexus of wide veins, analogous to the venous plexuses lie beneath and near the inner extremity of the lid at the spot where the tarsus terminates. They are situated upon small elevations, the lachrymal papillæ (*papillae lacrimales*), and form the orifices of the canaliculi lacrimales. These latter, starting from the puncta, run at first vertically for a short distance—i. e., in the upper lid run upward and in the lower lid downward; then they bend at a right angle and become directed toward the lachrymal sac. In so doing they first pass behind the caruncle, and converging more and more, at length reach the lachrymal sac. Into this they empty, either separately or after having united to form a short common trunk.

The Lachrymal Sac (*saccus lacrimalis*) lies in the inner angle of the eye in the cleft (*fossa sacci lacrimalis*) which the lachrymal bone forms for its reception. The lachrymal bone bounds the lachrymal sac on the inside, while to the front and outside it is inclosed by the two branches of the ligamentum palpebrale mediale. This relation of the lachrymal sac to the internal palpebral ligament enables us to determine the position of the former —a matter which is of importance when operations are concerned. If by drawing the lids outward we put them on the stretch and so cause the palpebral ligament to project, it can be seen that the lachrymal sac lies behind the latter, and in such a way as to rise just above it by its summit or fundus.

At the spot where the cleft of the lachrymal bone merges into the bony canal the lachrymal sac passes into the nasal or Lachrymal Duct (*ductus lacrimalis*). The point where this transition occurs constitutes the narrowest part of the whole lachrymal channel, and is, therefore, particularly liable to the formation of pathological contractions (*strictures*). From this point the lachrymal duct passes downward and empties into the nasal fossa below the inferior turbinated body beneath the mucous membrane of the turbinated bodies and is interposed between the mucous membrane of the lachrymal duct and the bony wall. The swelling of these veins is alone sufficient to contract or to close entirely the lumen of the duct.

The lachrymal passages are always filled with a small quantity of lachrymal fluid. If air is found in them, it is to be regarded as a pathological condition.

THE LACHRYMAL SECRETION contains only a few solid constituents, the main part of which is sodium chloride (*hence "salty" tears*). In the normal state the lachrymal gland secretes scarcely any more liquid than is lost by evaporation from the surface of the eyeball, so that but very small quantities of fluid are discharged into the nose. It is only when the secretion is increased, either in consequence of physical stimulation or of irritation of the eye, that any considerable quantity of tears is discharged into the nose, where its presence is manifested by repeated blowing of the nose.

The moistening of the eyeball is not due to the lachrymal glands alone. The secretion of the conjunctiva itself, and also of its mucous glands, participate in the performance of this act. Hence it follows that even after removal or degeneration of the lachrymal gland the eye does not become dry.

In the CONDUCTION OF TEARS into the nose there are two factors to be considered: the entrance of the tears into the lachrymal sac; and their transmission from the latter to the nose.

(a) The conveyance of tears through the puncta into the lachrymal sac is effected by the act of winking. This takes place in such a way that the palpebral fissure is closed by a movement beginning at the outer and extending to the inner angle of the eye. Since the tears cannot flow off over the border of the lid owing to the way in which the latter is lubricated with fatty matter, they accumulate in the horseshoe-shaped notch in the inner angle of the eye, and form the lacus lacrimalis into which the punctum dips. If there is a perfect and water tight closure of the lids, the pressure exerted by the latter at length forces the tears into the puncta. The passage of the tears into the lachrymal sac is facilitated by the passive dilatation of the latter that occurs as the lid is closing; for the fibers of the palpebral portion of the orbicularis arise in part from the internal palpebral ligament, and hence, in contracting as they do during the closure of the lids, draw the ligament away from the lachrymal bone. The anterior wall of the lachrymal sac being connected with the palpebral ligament, is drawn up at the same time with it, so that the lachrymal sac is dilated and the contents of the canaliculi are, so to speak, sucked into the sac.

(b) The conveyance of the tears from the lachrymal sac into the nose is due partly to the constant entrance of fresh charges of tears from the canaliculi and partly to the weight of the fluid; but the chief part in the process is performed by the elasticity of the lachrymal sac. In virtue of this elasticity the sac when distended by the tears tends to contract again and thus expel the tears. Hence, in those pathological cases in which the lachrymal sac has lost its elasticity (*atony of the sac*) we observe that the conduction of tears downward is arrested, even though the nasal duct is completely pervious.

The mucous membrane of the canaliculi is lined with laminated pavement epithelium; that of the lachrymal sac and nasal duct with a single layer of cylindrical epithelium. Acinous mucous glands are frequently found in the latter. The mucous membrane at different spots projects in the form of folds into the lumen of the lachrymal passages, a phenomenon which has been described as a formation of valves.

The largest of these folds is Hasner's valve, at the lower orifice of the nasal duct. This, however, is not a true valve, any more than are the others —that is, not a valve which could close up the lumen of the lachrymal channel. On the contrary, it is simply a fold produced by the great obliquity with which the nasal duct passes through the mucous membrane of the nasal fossa. Like the other folds of mucous membrane in the lachrymal passages, it is not of constant occurrence.

Duplication of the puncta and canaliculi, and also their absence, have been recorded as congenital anomalies.

Different theories have been put forth to account for the transmission of tears into the nose. It is certain that perfect closure of the lids forms an indispensable condition for the conduction of tears. If this closure is interfered with—e. g., by paralysis of the orbicularis, narrowing of the lids, notching of the border of the lids, etc.—epiphora at once makes its appearance. The passage of tears into the lachrymal sac takes place even when the rest of the way to the nose is cut off by the obliteration of the nasal duct. Hence it follows that the tears are not sucked into the lachrymal sac through the rarefaction of the air in the nose during inspiration.

THE EYEBALL.

THE EYEBALL is situated in the anterior part of the orbit, to its outer side and rests upon a cushion of cellular tissue and fat. It is protected in front by the eyelids. In form it is a sphere of about 25 mm. in diameter having the segment of a smaller sphere engrafted upon its anterior surface, which slightly increases its anterior posterior diameter. The axes of the two balls are parallel with each other, but do not correspond with the axis of the orbits, which are directed outward. The eyeball does not reach its full size until about 20 years of age. Its weight is about 95 grains. The eyeball is composed of tunics or coats and of refracting media called humours. The tunics are 3 in number. Named from without inward they are first sclerotica and cornea; second choroid, iris and ciliary processes; third retina and zonula cilaris.

THE FIRST TUNIC. THE SCLEROTIC AND CORNEA are the outside coats of the ball. Four-fifths of the ball is enveloped by the sclerotic; the remaining one-fifth by the cornea.

THE SCLEROTIC, from a Greek word meaning hard, is a tough white fibrous tunic or coat, and serves to give shape to the eye and protect its more delicate interior. THE SCLEROTIC is thickest at its posterior portion and gradually becomes thinner as it approaches the cornea, where it again thickens at the sclero corneal junction. Entirely within the sclera at the sclero corneal junction is the circular venous sinus (canal of Schlemm), which is the outlet, whereby the aqueous humor finds its way into the circulation.

The sclero corneal junction is beveled and receives the cornea in the same way as the crystal of a watch is received by the groove in its case.

THE CORNEA (*cornu, a horn*) is the transparent part of the external coat of the eyeball and projects beyond the curving surface of the sclerotic and is, therefore, the segment of a smaller sphere. In form it is slightly

elliptical, the vertical diameter measuring 11 mm., while the horizontal diameter measures 12 mm. The curvature of the posterior surface is somewhat greater than the anterior surface, the difference in the curvature resulting in an increase in the thickness of the edges, the edges measuring about 1 mm. A vertical section of the cornea shows it to consist of five layers:

1. The Anterior Epithelium.
2. Bowman's Membrane (Anterior elastic Lamina).
3. The Stroma (Substantia propria).
4. Descement's Membrane (Posterior elastic Lamina).
5. The Posterior Epithelium.

1. The Anterior Epithelium is a continuation of the conjunctiva and consists of pavement epithelium made up of cylindrical round and flat cells. It is thickest at the periphery and thinnest at the center of the cornea.

2. Bowman's Membrane is a delicate, thin, homogeneous membrane firmly attached to the lamellæ of the stroma. In pathological conditions and after death, the anterior epithelium separates very rapidly from Bowman's membrane.

3. The Stroma or true cornea forming 95% of the whole, is composed of a ground substance and of cells. The ground substance is composed of fine fibrillæ of connective tissue, united together by a cement substance into flat bundles arranged in nearly regular lamellæ. Between these lamella are open spaces which are filled with lymph and are called lymph spaces; these are connected with one another by small canals. Through these spaces and canals circulate the lymph upon which the cornea is dependent for its nourishment. Circulating also in these canals and spaces are a few white blood corpuscles. In the normal eye they are very few in number, but as soon as any pathological condition occurs these white blood corpuscles escape from the net work of blood vessels at the margin of the cornea and increase very rapidly and play a very important part in any inflammation of the cornea.

4. Descement's Membrane is a thin homogeneous hyaloid membrane which serves to give the cornea its correct curvature. It is very resistant to all pathological changes and when the entire cornea is broken down into pus, this membrane will remain unimpaired for days.

5. The Posterior Epithelium is a single layer of flattened cells lining the posterior surface of Descement's membrane.

The Corneal Nerves arise partly from the terminal branches of the long ciliary and partly from the nerves of the bulbar conjunctiva. They are abundantly distributed to the upper-most layers of the stroma directly beneath Bowman's membrane. Owing to the large nerve supply lesions of the cornea are particularly painful.

The Second Tunic is composed of the Choroid, Ciliary Body and Iris. It lines the inner side of the sclerotic, is perforated posteriorly by the optic nerve, and in front has a circular opening called the pupil.

The Choroid is a vascular membrane of a rich chocolate brown color upon its internal surface and a deep black within. It lies between the

sclerotic and retina and extends from the optic nerve to the ciliary body. It is pierced posteriorly for the passage of the optic nerve and is connected anteriorly with the iris, ciliary processes and with the line of junction of the cornea and sclerotic, by a dense white structure, the ciliary ligament, which surrounds the circumference of the iris like a ring. The choroid membrane is composed of three layers: external, middle and internal. The external layer is composed largely of veins and has been named Venæ Vortecosœ. The middle is composed largely of minute arteries. The internal layer (or membrana pigments) as its name implies is composed of pigment cells. The presence of these cells give the black appearance to the choroid.

The Ciliary Body is composed of the Ciliary Muscle and the Ciliary Process and is that portion lying between the choroid and iris. It is continuous with both, and is about ¼ of an inch in width.

The Ciliary Muscle is composed of circular and radiating fibres. The circular fibers occupy that portion of the ciliary body near its junction with the iris, while the radiating fibers are confined to the outer portion of the ciliary body arising tendinously from the sclero-corneal junction, the posterior elastic lamina, and from the ligamentum pectinatum iridis, and are directed backward and inward where they terminate in the choroid.

The Ciliary Process is formed by folds (*processes*) of the choroid at its interior margin. The folds or processes form a circle behind the lens and cover the inner surface of the ciliary body. They are deepest and thickest at their forepart and gradually taper into the choroid. Within the folds of the ciliary processes are received the corresponding folds of the suspensory ligament, which is also called Zonula Zinnii.

The Iris is a disk-shaped membrane of about one-half inch in diameter (*12 m*), perforated in the center, which perforation is called the pupil. By its peripheral or ciliary border it is continuous with the ciliary body and is held in position by the pectonate ligament and also by the anterior capsule of the crystaline lens upon which the pupillary border rests.

The anterior surface of the iris is lined with a continuation of the posterior epithelium of the cornea, and if examined closely is found to be composed of elevations and depressions, which are caused by the blood vessels lying in the stroma of the iris and running from the ciliary to the pupillary margin. Near the pupillary margin these vessels interlace with a ring of circular ridges. This divides the iris into two zones: the ciliary zone and the pupillary zone.

The posterior surface of the iris is covered by the posterior lining membrane and the retinal pigment layer, which layer gives the different colors to the iris. The color of the irides in the same individual are, as a rule similar, but there are instances of congenital differences in color in perfectly normal irides.

The iris, by its ability to open and close, makes the pupil larger or smaller and regulates the amount of light which enters the eye. Ordinarily the pupil is about one-eighth to one-fifth of an inch (*3 to 5 mm.*) in diameter. It should be round and promptly react to light stimulation. Under the same illumination both pupils should be uniform in size. If one eye should be shaded the pupil of the shaded eye should act in harmony with the one exposed to light. This is termed the consenual action of the pupils.

If the iris be thin and the rays of light pass through its substance, they are immediately absorbed by the uvea, and if that layer be insufficient, they are taken up by the black pigment of the ciliary process. In Albinos, where there is an absence of the black pigment, the rays of light traverse or pass through the iris, and even the sclerotic and so overwhelm the eye with light, that the sight is very much diminished, except in the dimness of evening. In the manufacture of optical instruments, care is taken to color their interior black with the same object, the absorption of all extraneous rays of light.

THE THIRD TUNIC, or inner tunis of the eye, is the RETINA, a thin, delicate membrane formed from the fibers of the optic nerve. In the living eye it is perfectly transparent and of a purplish red color. The retina is composed of two kinds of tissue, the nervous tissue and the supporting tissue. The function of the latter is to maintain and support the extremely delicate nervous tissue. The retina is attached at the entrance of the optic nerve and at the ora serrata. It is not attached to the choroid, but simply lies on it.

An examination of the normal eye with the ophthalmoscope reveals the optic disk, the retinal vessels and the macula lutea, which is the thinnest part of the retina and the part that has the most delicate perception; this is also called the fovea centralis, yellow spot. When we wish to get a precise perception of an object we so adjust our eye that the image shall fall upon this point. We fix the object or bring it within our central vision.

In contradistinction to central vision, we have peripheral or indirect vision, which is vision with all the balance of the retina. The farther from the fovea centralis the image is produced upon the retina, the less distinct is the perception of its shape. The images falling upon the periphery of the retina give us warning signals, which make us cast our eye directly upon the objects which excite the image. Peripheral vision is, therefore, very important in walking.

The microscope shows the retina to be composed of ten different layers. They are as follows:

1. *Membrana limitans interna.*
2. *Fibrous layer.*
3. *Vesicular layer.*
4. *Inner molecular layer.*
5. *Inner nuclear layer.*
6. *Outer molecular layer.*
7. *Outer nuclear layer.*
8. *External limiting membrane.*
9. *Jacob's membrane or rods and cones.*
10. *Pigmentary layer.*

Jacob's membrane or rods and cones is the most important part of the retina, as it is connected by nerve-fibrils with the layer of nerve fibers which convey the visual impressions through the optic nerve to the brain. The optic nerve collects its fibers from the retina. It pierces the choroid and sclera and comes out a little to the nasal side of the posterior pole of the eye. This portion of the nerve is called the intra ocular, while the part extending from the back of the ball to the optic foramen is called the orbital, and that part extending from the foramen to the optic chiasm is called the intra

cranial, so that we have the optic nerve divided into three portions: THE INTRA OCULAR, THE ORBITAL *and* THE INTRA CRANIA. It is about one-sixth of an inch in diameter (*4 mm.*) and is supplied by blood vessels from the ophthalmic artery. The optic disk is that portion of the optic nerve included within the margins of the choroidal foramen. It is usually round in shape and is pierced in the center by the central retinal artery and vein. Both the artery and vein bifurcate, one branch of each passing vertically upward and the other downward to the retina. By the aid of the ophthalmoscope the vein can easily be recognized from the artery by its size and color.

THE HUMORS OF THE EYE BALL. THE AQUEOUS HUMOR is a clear, colorless, transparent liquid filling the anterior and posterior chambers of the ball. It is faintly alkaline and has a sp. gr. of about 1005. It is secreted by the ciliary processes and the posterior surface of the iris. If the anterior and posterior chamber should be evacuated by accident or by an operation the aqueous humor is rapidly reproduced.

THE VITREOUS HUMOR is a transparent, colorless, gelatinous mass which fills the vitreous cavity. It is surrounded by a transparent capsule called the hyaloid membrane. The anterior portion of the vitreous humor has a deep depression called the hyaloid fossa. It is within this fossa that the posterior portion of the crystalline lens rests. Beginning at the papilla of the optic nerve and extending to the posterior surface of the crystalline lens is a canal (canalis hyaloideus). During foetal life the hyaloid artery runs into this canal. In the fully developed eye it probably serves as a lymph channel.

The principal function of the vitreous humor is to hold the retina in place.

THE CRYSTALLINE LENS lies within the circle formed by the ciliary processes, and is kept in position by the suspensory ligament or zonula ciliaris. In this position it divides the eye into a smaller anterior and a larger posterior section. It is a transparent and colorless structure of lenticular shape, the anterior surface of which is less, the posterior surface more curved. It causes the rays of light to focus, in the normal eye, upon the retina.

The function of the lens is to enable us to see distinctly all objects within the range of vision, no matter at what distance. This is spoken of as the power of accommodation. We can easily convince ourselves that the normal eye possesses such a power, when we go to a baseball game and sit back of the wire screen. We cannot see the screen and the player at one and the same time. Another proof is found in the veils worn by women. This power of accommodation is brought about by an alteration of form of the lens, its anterior surface becoming more convex and approaching the cornea. This alteration in form is accomplished by the ciliary muscle. When we arrive at a certain age, which is about 45, if the eye was normal at birth, we require spectacles for close work. This is due to the fact that at this time in life the ciliary muscle loses some of its elasticity, and as a consequence has not this ability to maintain the effort required in accommodating. When this occurs we designate it as presbyopia, which means old sight.

THE OCULAR MUSCLES OF THE EYE are divided into the external extrinsic, and the internal intrinsic.

THE EXTERNAL (*extrinsic*) MUSCLES control the movement of the eye ball and are the four recti (straight) muscles and the two oblique muscles. All six of these muscles are named from their relative positions: superior, inferior, external and internal.

THE FOUR RECTI MUSCLES take their origin from around the optic foramen. They come forward and are attached, as their names indicate, by means of short tendons which spread out in the form of a fan and become fused with the sclera.

THE TWO OBLIQUE MUSCLES, the superior and the inferior, have a more complicated course.

THE SUPERIOR OBLIQUE arises from the margin of the optic foramen and runs forward upon the upper and inner wall of the orbit, to the upper and inner margin of the orbit. It here passes through a firm fibrous loop, known as the trochlea. From here it bends back at an acute angle and passes beneath the superior rectus to the eyeball. Here it spreads out and is inserted into the upper half of the ball about in the vertical meridian and behind the equator.

THE INFERIOR OBLIQUE arises from the orbital plate of the superior maxillary, and from here it runs upward and outward and is inserted about in the horizontal meridian and also behind the equator of the ball.

THE NERVE SUPPLY OF THE EXTERNAL MUSCLES is derived from the sixth cranial or abducens, the third cranial or motor oculi, and the fourth cranial or patheticus. The sixth cranial supplies the external rectus. The third cranial supplies the internal rectus, the superior rectus the inferior rectus and the inferior oblique. The fourth cranial supplying the superior oblique.

THE INTERNAL MUSCLES of the eye are the sphincter pupillæ and the ciliary muscle.

The eye balls and their appendages receive their blood supply from the branches of the ophthalmic artery.

THE SUPRA-ORBITAL ARTERY supplies the superior rectus and levator palpebræ.

THE SUPERIOR PALPERBRAL ARTERY supplies the upper lid.

THE INFERIOR PALPEBRAL ARTERY supplies the lower lid.

THE LACHRYMAL ARTERY supplies the lachrymal glands and the conjunctiva.

THE NASAL ARTERY supplies the lachrymal sac.

THE SUPERIOR MUSCULAR ARTERY contributes to the levator palpebræ, superior rectus and superior oblique muscles.

THE INFERIOR MUSCULAR ARTERY contributes to the external rectus, inferior rectus and inferior oblique muscles.

THE INFRA-ORBITAL ARTERY supplies the inferior rectus and inferior oblique muscles (a branch of the internal maxillary artery).

THE SHORT CILIARY ARTERIES, about twelve in number, enter the sclerotic around the optic nerve entrance and supply the choroid and ciliary processes.

THE LONG CILIARY ARTERIES (two in number) enter the sclerotic on each side of the optic nerve, coming forward between the sclerotic and choroid to the ciliary ligament, where they divide into two branches, forming the circulus iridis, major and minor.

THE BLOOD SUPPLY of the external muscles is derived from the ophthalmic artery.

The veins of the muscles empty into the ophthalmic and facial veins.

If we disregard the conjunctiva, there are no lymphatic vessels in the eye. They are replaced by lymph channels and lymph spaces. These are divided into two portions, the anterior lymphatic system and posterior lymphatic system. The lymph of the anterior system is collected into the anterior and posterior chambers of the ball, which chambers communicate by means of the pupil. The lymph is secreted from the iris and ciliary processes flowing from the posterior chamber through the pupil into the anterior chamber. From here it filters through the sieve work of the ligamentum pectinatum into the subjacent canal of Schlemm, and from here gets directly into the anterior ciliary veins.

By far the greatest amount of lymph leaves the eye through the anterior system, and this, therefore, is more important than the posterior system.

The posterior lymphatic system occupies the hyaloid canal, perichoroidal space and tenon's space. The outflow of lymph from these spaces passes into the lymph passages, which spread out along the optic nerve. The passages are found between the sheaths of the optic nerve (the intervaginal space and around the sheaths called the supravaginal).

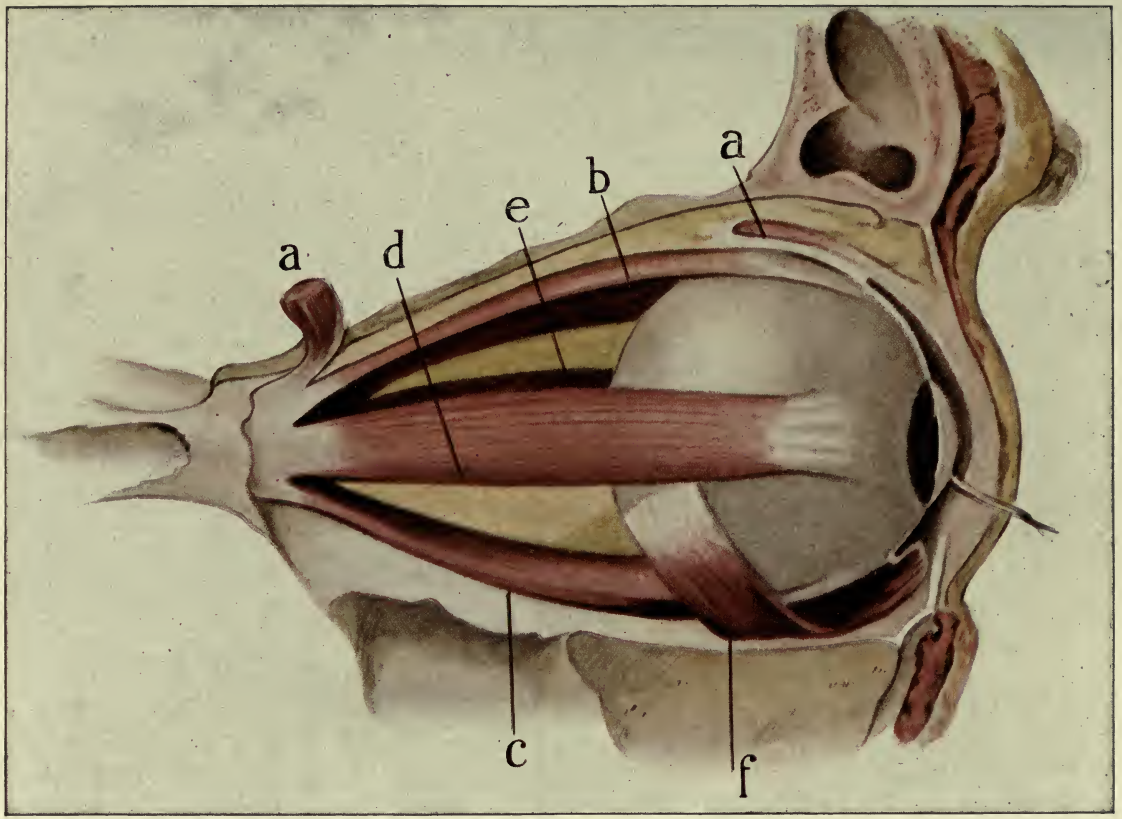

PLATE 2

a, *a*, Levator palpebrae superior. *b*, Superior rectus. *c*, Inferior rectus. *d*, External rectus. *e*, Internal rectus. *f*, Inferior oblique. The muscles shown in this illustration are shown in profile.